Claims

1. A three-dimensional food product, elongated in at least one dimension (the z-dimension) and consisting of at least two components which have been coextruded to become interspersed with each other, in which one or more cells of components A are surrounded at least in the xz plane by one or more components B which form cell walls surrounding the A component characterised in that the or each B component is a solid (including a viscoelastic solid) at 20°C the cells of components A are arranged in at least two mutually distinct rows extending generally in the z direction, each said row of cells being separated from the adjacent row by a generally continuous (in the z-direction) boundary cell wall of B component, and either a) A having no compressional yield point (being a fluid) at 20°C or having plastic, pseudoplastic or viscoelastic consistency at 20°C and having a compressional yield point YP_{A20} at 20°C which is less than 0.5 x the compressional yield point of B at 20°C (YP_{B20}) or b) A being an expanded material containing at least 50% by volume gas.

2. A product according to claim 1 in which each cell of A extends in a generally Y direction substantially from a position at or adjacent to one xz face of the food product to a position at or adjacent the other xz face.

3. A product according to claim 1 in which the boundary cell wall is formed of a component B_1 and the product has bridging cell walls branching from and extending at least part way in a generally x direction towards the adjacent boundary cell wall, the bridging cell walls being formed at least in part of a B component B_2 being different to B_1.

4. A product according to claim 1 in which the boundary cell wall is formed of at least two different components B_1 and B_2 and the product has bridging cell walls branching from and extending at least part way in a generally x direction towards the adjacent boundary cell wall, the bridging cell walls being formed at least in part of B_2.

5. A product according to claim 3 or claim 4 in which the components B_1 and B_2 have different yield points at 20°C, preferably in which the yield point of B_1, $YP_{B1(20)}$, is in the range 0.1 to 0.5 of the yield point of B_2, $YP_{B2(20)}$.

6. A product according to claim 1 in which each of the cells of A extend part way between the two xz faces, and in which two or more cells span the distance between the two xz faces and are separated from one another in the y-direction and in which there are B components arranged between adjacent cells of A which are separated from one another generally in the y direction and forming cell walls around each A cell, so that the A cells are substantially enveloped by cell walls of B.

7. A product according to claim 6 and claim 4 in which the B components between adjacent cells of A separated in the y-direction comprises B1.

8. A product according to claim 1 in which the B component is formed of a single component and in which there are bridging cell walls branching from and extending at least part way in a generally x direction towards the adjacent boundary cell wall and around each cell of A.

9. A product according to claim 1, characterised in that if the bridging cell walls that is walls other than the boundary cell are attenuated in the vicinity of the boundary cell wall the local thickness the attenuated wall is generally not any thinner than 1/15 of the thickest portion of said wall.

10. A product according to claim 8, characterised in that the said boundary cell walls of B-component extend in waved or zig-zagging manner about a plane extending in the zy plane.

11. A product according to any of claims 5 to 10 in which the bridging cell walls which branch off from the boundary cell walls, considered in a yz plane, branch off substantially perpendicularly to the boundary cell wall at the branching point.

12. A product according to any preceding claim which further comprises edge boundary cell walls of B extending substantially continuously generally in the z- direction along or adjacent to each yz face of the product.

13. A product according to claim 1 in which each boundary cell wall is substantially planar, lying generally in a yz plane.

14. A product according to any preceding claim in which the cross section of cells of A in the xz plane has an average dimension in the z direction in the range 0.5 to 10 mm, preferably in the range 1-5 mm.

15. A product according to any preceding claim in which the average cross-sectional area of cells of A in the xz plane is in the range 0.5-100mm^2, preferably 1-25mm^2.

16. A product according to any preceding claim in which the average row separation is in the range 1-25mm, preferably 3-15mm.

17. A product according to claim 16 in which the boundary cell walls have a minimum thickness in the x direction in the range 5-50% of the average row separation, preferably at least 10%.

18. A product according to any preceding claim in which the bridging cell walls (being cell walls between cells of A other than boundary cell walls) have a minimum thickness of 0.1 mm, preferably a minimum thickness of 0.5 mm.

19. A product according to any preceding claim, characterised in that A in the final form of the product at 20°C is fluid.

20. A product according to any of claims 1 to 18, characterised in that A in the final form of the product at 20°C is a plastic pseudoplastic or viscoelastic material cell having a compressional yield point, YP_A lower than 1000 g cm^{-2} and preferably lower than 500 g cm^{-2}.

21. A product according to claim 20, characterised in that A consists of a blend of on one hand short fibres, nut-, grain- or shell-pieces, film-pieces or flakes and on the other hand a water based solution or gel.

22. A product according to claim 20, characterised in that A consist of a blend of on one hand short fibres, nut-, grain, or shell-pieces, film-pieces or flakes, and on the other hand an oil.

23. A product according to any preceding claim, characterised in that B is a gel.

24. A product according to any preceding claim in which B, optionally reinforced with short fibres, or grain-, shell- or film-pieces or flakes, has a yield

point, YP_B, of at least 200 g cm^{-2}, preferably in the range 500 to 80,000 g cm^{-2}, and more preferably no more than 60,000 g cm^{-2}.

25. A product according to any preceding claim, <u>characterised in that</u> B is based on fat, oil or wax with additions for the taste, preferably it consists of chocolate.

26. A product according to any of claims 1 to 24, <u>characterised in that</u> B is based on protein.

27. A product according to any of claims 1 to 24, <u>characterised in that</u> B is a microporous agglomerate of particles containing water in the pores, and that the said particles consist of short fibres or grain-, shell- or film-pieces or flakes, which particles are bonded together by polymeric micro-strands, e.g. consisting of coagulated gluten or a natural or synthetic rubber as produced by coagulation of a latex.

28. A product according to any of claims 1 to 24, <u>characterised in that</u> B is or contains a gel based on a polymer belonging to the group of carbohydrates or carbohydrate related compounds.

29. A product according to claim 1, <u>characterised in that</u> B comprises a polymer and the boundary cell walls of B extending in a generally z direction are molecularly oriented in the general z direction.

30. A product according to claim 1, <u>characterised in that</u> A is a juice optionally in form of a soft gel or with a thickening agent and being flowable, and that A contains dissolved sugar.

31. A product according to claim 1, <u>characterised in that</u> A is a juice optionally in form of a soft gel or with a thickening agent, and that A contains hydrolysed proteins to give it taste and nutritional value comparable to meat.

32. A product according to claim 1, <u>characterised in that</u> A contains a pulp of short protein fibres or pieces of protein film.

33. A product according to claim 1, <u>characterised in that</u> A is a cultured milk product.

34. A product according to claim 1, <u>characterised in that</u> A is marzipan.

35. A product according to claim 1, characterised in that A is a paste based on meat.

36. A product according to claim 1, characterised in that the A component contains gas.

37. A bread or cake product according to claim 36, characterised in that A is based on expanded and baked starch and B is based on protein.

38. A product according to claim 36 characterised in that B comprises cheese.

39. A product according to claim 1, characterised by containing two different A-components, A1 and A2.

40. A product according to claim 39 in which A1 is a waterbased solution or gel or contains such solution or gel as matrix for solid particles, and A2 is fat- or oil-based or contains fat or oil as matrix for solid particles.

41. A three dimensional solid (including viscoelastic solid) food product elongated in at least one dimension (the z-dimension) and consisting of at least two components having different visual appearance which have been coextruded to become interspersed with one another in which there are segments of A and segments of B, characterised in that the or each B component is a solid (including a viscoelastic solid) at 20°C the or each A component is a solid (including a viscoelastic solid 20°C), the segments of A are arranged in at least two mutually distinct rows extending generally in the z-direction, and in which the rows of A and interspersed B are visible at at least one surface of the product extending in a general xz plane.

42. A product according to claim 41 in which the thickness of the segments of A and the segments of B are attenuated close to the border between two rows is as compared to their thickness at points distant from the boundary cell walls (where the thickness at any point is the shortest distance across the segment at that point) and in which the segments are dragged out so as to form an acute angle of less than about 45° with the z-direction in the xz plane.

43. A product according to claim 41 or 42 in which A and B consist of one of the following combinations:

a) darker chocolate/ligther chocolate

b) chocolate/marzipan

c) chocolate/caramel

d) two differently coloured gums or fruit gels.

44. A method of manufacturing by coextrusion in an extrusion die a food product in which the components are extruded in a z-direction from the extrusion die, and in which at least one extrudable component A' is formed into a flow through a channel and an extrudable component B' is formed into a flow through a channel, the flow of B' being x-wise adjacent to the flow of A', x being transverse to z, in which the flows of A' and B' exit from the channels through exits after which, the flows of A' and B' are regularly divided in a generally x-direction by a dividing member to form at least two rows of flows of A' and B' separated in the x-direction, in each of which row the flows of A' and B' segmented in the z direction and in which in each said row a segment of flow of B' is joined upstream and downstream to each segment of flow of A' whereby B' segments are interposed between adjacent A' segments in the z direction and in which adjacent rows are joined to one another along their yz faces, each row of segmented flows of A' forming a row of cells of A' extending generally in the z direction and wherein after the joining of the segmental flows B' is transformed to a solid material (including a viscoelastic solid) B, or, if B' is already viscoelastic, is transformed to a material B having a compressional yield point which is at least twice that of B'.

45. A method according to claim 44 in which after the said joining the material A' is expanded to at least twice the volume of A', or, if A' is plastic, pseudoplastic or viscoelastic is transformed to a material A having a lower yield point than the yield point of A' by a factor of at least 2 or to a fluid, or, where A' is a fluid, is transformed to a fluid A having an apparent viscosity less than half that of A'.

46. A method according to claim 44 or claim 45, characterised in that the extrusion is carried out at an elevated temperature and the transformation of B' takes place by cooling.

47. A method according to claim 44 or claim 45, characterised in that the said transformation of B' takes place by coagulation or gel formation.

48. A method according to claim 47, characterised in that the coagulation or gel formation is established by heating.

49. A method according to claim 47, characterised in that prior to the coextrusion process B' is formed as an extrudable material by disruption of a continuous, firm gel structure, and after the end of the coextrusion the continuous firm structure of this gel is reestablished by heating followed by cooling, or, if the gel is adequately thixotropic, spontaneously or upon storage.

50. A method according to claim 47, characterised in that the coagulation or gel formation is carried out by chemical reaction.

51. A method according to claim 50, characterised in that when the gel formation can be made sufficiently slow, the gelling reagent or coagulant is incorporated into B' prior to the coextrusion process.

52. A method according to claim 51 in which the reagent or coagulant is incorporated into solid particles suspended in B'.

53. A method according to claim 51 in which the gel formation or coagulation is enzymatic, for instance involving a protease such as rennin to break down and coagulate milk protein.

54. A method according to claim 47, characterised in that the gel formation or coagulation is established by including a reactant in the A', this reactant gradually migrating into B' component when the components are brought together in the coextrusion die.

55. A method according to claim 54, characterised in that the transformation partly occurs by precipitation in the B' of an inorganic salt, e.g. calciumphosphate, formed by reaction between ions in A' and ions in B'.

56. A process according to claim 51, characterised in that by a chemical reaction preformed solid particles are coagulated to continuous firm material.

57. A method according to claims 44 or claim 45 in which B' is water-based and the transformation of B' takes place by cooling to a temperature below the freezing range of B'.

58. A method according to claim 44 or claim 45, <u>characterised in that</u> during the extrusion B is mainly in the form of a firm material in particle form suspended in water, and after the end of the extrusion at least a part of the particles are first fused and then transformed by cooling to make the material cohesive.

59. A method according to claim 44 or claim 45, <u>characterised in that</u> in order to operate the extrusion process with A' in suitable extrudable state but achieve a more flowable consistency or lower yield point of A in the final product, A' is cooled prior to the extrusion sufficiently partly to solidify (including precipitate) a major portion at least of the material in A' as particulate suspended solids and after the extrusion the particulate solids are melted or redissolved.

60. A method according to claim 44 or 45 <u>characterised in that</u> in order to operate the extrusion process with B' in suitable extrudable state but achieve a more flowable consistency or lower yield point of B in the final product B' is cooled prior to the extrusion sufficiently partly to solidify (including precipitate) a major portion at least of the material in B' as particulate suspended solids and after the extrusion the particulate solids are melted or redissolved.

61. A method according to claim 60 in which B1 and B2 are formed of the same composition but are of different materials.

62. A method according to claim 44 or claim 45, <u>characterised in that</u> in order to operate the extrusion process with A' in suitable extrudable form but achieve a more flowable consistency of A in the final product, A' is applied to the extrusion process in said state by including in A' a polymer in dissolved or suspended particulate form, which is depolymerised at least in part after finalisation of the extrusion process.

63. A method according to claim 62, <u>characterised in that</u> the depolymerisation process is enzymatic.

64. A method according to any of claims 44 to 63 which A' is formed into at least two flows separated from one another in the x direction and in which B' is formed into at least two flows separated from one another in the x

direction and in which flows of B' are interposed between part of adjacent flows of A'.

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65. A method of coextruding two materials A' and B' in an extrusion die in which at least one extrudable component A' is supplied from a reservoir for A' and is formed into a flow through an extrusion channel to an exit for A' from the channel, and at least one extrudable material B' is supplied from a reservoir for B' and is formed into a narrow flow through an extrusion channel to the exit for B' from the channel in which the flows of A' and B' are each divided at or after the respective channel exits to form segments of respective extrudates each by a dividing member which moves relative to the extruder exit from a first position in which the respective channel exit to a second position the dividing member has traversed the entire channel exit, and the flows of both A' and B' out of the extrusion channels are intermittent in nature, controlled either by providing a ram close to or within each channel which drives the flow intermittently or by opening a valve between the inlet to the respective extrusion channel and the reservoir from which the component is supplied under pressure, the movement of the ram or the opening of the valve, as the case may be, being co-ordinated with the relative movement between the dividing members and the channel exits such that material is driven through the exits while the relative movement is stopped in said first and second positions, but is not driven through the exits during the change of positions.

66. A method according to claim 65 in which each ram is operated in a series consisting of more than one inward step, preferably at least 5 inward steps, for instance up to 20 inward steps, and in which after a series of inward steps the ram is retracted.

67. A method according to claim 65 or claim 66 and in which A' is fed from the respective reservoir into a feeding slot which feeds into each of the channels for A', and B' is fed from the respective reservoir into a feeding slot which feeds into each of the channels for B' and in which a single ram is driven to the feeding slot to drive material through the slot and in which the ram is driven into the feeding slot preferably in a series of more than one inward step; preferably at least 5 inward steps, for instance up to 20 inward steps, and in

which, after a series of inward steps the ram is retracted and the feeding slot filled with extrudable material from the respective reservoir.

68. A method according to any of claims 65 to 67 in which there is a segment of flow of B' joined both downstream and upstream to each segment of flow A' is joined to.

69. A method according to claim 68 in which at least two x-wise adjacent z-wise extending rows of segments of A' and segments of B' are joined to one another along their generally zy faces.

70. A method according to claim 44 or 69 in which the rows are joined in a collection chamber and in which the sheet that is formed is preferably taken off on a conveyor.

71. A method according to claim 44 or claim 68 in which, after the exit from the extruder B' is modelled around A' segments so as to surround the A' segments substantially completely in an xz plane.

72. A method according to claim 71, <u>characterised in that</u> the said modelling is effected by selecting a B' which under the process conditions is a fluid or has a compressional yield point which is significantly lower, preferably by a factor of at least 2, than that of A', and if this provision is not sufficient to avoid sticking of the A-component to the dividing members, further adding a adding a food acceptable release agent such as e.g. cream to the A-component.

73. A method according to claim 68 or 71 , <u>characterised in that</u> in order to establish or facilitated the modelling of component B' around the segments of component A' flows of component B' are merged with each flow of A' before this meets the extruder orifice, this merging being on both sides (in the x direction) of A' to form a composite flow of B'A'B' configuration.

74. A method according to claim 73 in which there are several x-wise separated composite flows B'A'B' and the orifices through which such composite B'A'B' streams are extruded alternate (generally along the x-direction) with orifices through which plain B component is extruded, whereby immediately after the dividing the segmental streams will consist a transverse row of B'A'B' segments alternating with B' segments.

75. A method according to claim 72, in which there are two B' components B1' and B2' to become modelled together around each segment of A', and in which B1' is merged with A' to form composite flows B1'-A'-B1' as defined in claim 73, <u>characterised in that</u> B1' in a similar manner is merged with B2' to form composite flow B1'-B2'-B1', and the orifices for the composite B1'-A'-B1' flows alternate (in a generally x-direction) with the exits for the composite B1'-B2'-B1' flows whereby immediately after the dividing the segmental streams will consist of a transverse row B1'-A'-B1' segments alternating with B1'-B2'-B1' segments.

76. A method according to claim 73, <u>characterised in that</u> the said merging is carried out in such a way that there is also formed a B'A'B' configuration when the composite stream is viewed in xy section through A, or optionally a configuration with a longer sequence of alternating B' and A' segments, B' being at the beginning and end of this sequence.

77. A method according to any of claims 44 to 76 in which each dividing member reciprocates relative to the or each extruder exit.

78. A method according to claim 77 in which the dividing members move in a plane, or on a circular cylindrical surface.

79. A method according to claim 78 in which x is substantially vertical and y is substantially horizontal and in which the reciprocation is in a substantially vertical plane (xy plane) or is about a horizontal axis.

80. A method according to any of claims 44 to 79, <u>characterised in that</u> the dividing members are installed in fixed dieparts, while the assembly of channels and orifices moves.

81. A method according to any of claims 44 to 79, <u>characterised in that</u> the orifices are installed in a fixed diepart, while the dividing members are installed in a reciprocating or rotating diepart.

82. A method according to any of claims 44 to 81, <u>characterised in that</u> each orifice is arranged in close proximity to or directly contacting the or each dividing members, whereby the dividing takes place by the shear between the exit walls and the dividing member.

83. A method according to claim 82, characterised in that the dividing of each flow to segments is performed by a cutting action.

84. A method according to claim 83, characterised in that the cutting is performed by forming the upstream end of the or each dividing member generally as a knife at least on one x-directed side of the dividing member, the edge of the knife pointing generally in a direction parallel to the said relative movement.

85. A method according to claim 83 or 84, characterised in that the cutting is performed by forming the or each of the orifices walls generally as a knife at least on one x-directed side, the edge of the knife pointing generally in a direction parallel to the said relative movement.

86. A method according to claim 83 or 84, in which to enhance the effect of cutting, the or each orifice and/or the or each dividing member performs relatively fast and relatively small vibrations relative to each other generally in the y-direction these vibrations being in addition to the slower and bigger reciprocations along the direction defined by the line of orifices, whereby the knives perform a sawing action.

87. A method according to claim 65 in which the pressure in each reservoir is controlled in coordination with the movement of the rams whereby extrudable material is driven from the reservoir as the ram is retracted but is not driven from reservoir as the ram is driving material through the channel.

88. A method according to claim 87 in which there is a non-return valve between each reservoir and the respective channel preventing return of material in the channel-reservoir direction.

89. A method according to claim 88 in which the non-return valve is at the inlet into each channel.

90. A method according to claim 63, characterised in that the division between the channels for A' and the division between the dividing members are adjusted to each other and at least component A' is extruded in a rhythm syncronized with the relative reciprocation or rotation between the orifices and dividing members in manner to produce maximum driving force on the

component while each of the orifices for the component is aligned with a space channel formed between a pair of dividing members.

91. A method according to claims 67 and 80 in which the assembly of channels and orifices is pressed against the fixed assembly which comprises the feeding slots during refilling of the channel with extrudable material and pressure is released at least in part while the movement of the movable assembly takes place.

92. A method according to claim 44 or 64, characterised in that in the dividing process a layer of B' is formed on each generally xz face of the product by making the or each orifices from which B' flows extend beyond in the y direction the internal orifices from which A' flows whereby B' extruded through the orifice will be sheared out to form said layers.

93. A method according to any of claims 44 to 92, characterised in that in the dividing process there is also interposed one or more layers of B' between adjacent segments of A' separated from one another in the y-direction by making each internal orifice for A' interrupted at one or more locations along the y axis without making the orifices for B' interrupted, whereby the shear will establish the interposing and formation of the layer or layers of B' extending in a generally xz plane.

94. A method according to claim 93 in which the or each orifice for A' are provided with ribs extending across the exit in a generally x direction to create the said interruptions, and in which B' is sheared over the surface of A' segments by provision of shear plates each of which is aligned to be in the same generally xz plane as the respective ribs.

95. A method according to claim 75, characterised in that B2 is formed into a gel at least in part while it proceeds as flows towards the dividing process.

96. A method according to claim 65, characterised in that a lubricant capable of forming a harmless part of the product is injected around the or each said ram in amounts sufficient to follow the extrudable component acted on by the ram device, thereby also lubricating the walls of each channel through

which the component is extruded to significantly reduce the backpressure created by the extrusion through the channel.

97. A method according to claim 73 in which the merging of A' and B' flows takes place in an internal die comprising a central channel through which A' flows and a peripheral channels on each x-wise side of the central channel through each of which B' flows the central channel having valve means allowing closing of the central channel to minimise flow of B' into the central channel.

98. A method according to claim 97 in which the value means are actuable by controlling the pressure in the flows of A' and B' and preferably comprise springy blades extending along each side of the central channel joined thereto by fluid tight, joins along one long blade edge, the blades being of suitable size and springiness that they meet at their opposite long edges to close the channel.

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99. A method of manufacturing by coextruision of a food product in sheet, ribbon or filament form, which product consisting of at least two components A and B, segments of B being in contact with segments of A, in which flows of A' and B' are coextruded from orifices of an extrusion die and, after extrusion, B' is transformed to a solid material (including a viscoelastic solid) B, or, if B' is already viscoelastic, is transformed to a material B having a compressional yield point which is at least twice that of B', in which B' is transformed by coagulation or gel formation initiated by a coagulant or gelling reagent incorporated in A'.

100. A method according to claim 97 in which the coagulant or gelling reagent is an enzyme, preferably a protease, for instance rennin.

101. A method according to claim 98 in which B' comprises a protein, for instance milk protein.

102. Apparatus suitable for carrying out a process according to claim 44, comprising an extrusion die having channels for flow of two different extrudable materials and orifices for exit in a generally z direction of material from the channels which are separated from one another in the x direction, further comprising dividing members capable of producing at least two rows of flows of extrudate by moving across the orifices to divide the flows in a

generally x direction, and comprising further means for subjecting the product to conditions to transform components of the product form a relatively soft material to a relatively hard material.

103. Apparatus suitable for carrying out a process according to claim 65, comprising an extrusion die having channels through which at least two different materials may flow, means for driving the material through the channels and out of orifices which are separated from one another in the generally x direction, and having dividing members which are capable of moving across the orifices to divide the flows of extrudate therethrough in a generally x direction, in which the movement of the dividing members and the driving of the material through the channels are controlled so that material is diriven through the orifices while relative movement between the dividing members and the orifices is stopped.

104. Apparatus according to claim 102 or 103, further having features as described herein.

105. Apparatus as described herein and substantially as illustrated in the drawings.